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INTRAOCULAR LENS
[Gan'nai ren'zu]

Tsutomu Hara, et al.

UNITED STATES PATENT AND TRADEMARK OFFICE
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INVENTOR	(72):	HARA, TSUTOMU; YASUDA, AKIHIRO; KUMAZAWA, YUTAKA; YAMADA, YOSHIHARU.
APPLICANT	(71):	MENICON CO., LTD.
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Specifications

/279*

1. Title of the Invention

Intraocular Lens

2. Claim

An intraocular lens used by being inserted into a crystalline lens capsule; said intraocular lens characterized by including (a) an optical lens comprising a light-transmitting material having a convex lens function, (b) at least one holding portion wherein the part of it corresponding to the optical path of light being perceived serves as a light transmission-permitting portion to permit the transmission of light, (c) and a coupling means which elastically couples the optical lens portion and holding portion in a state in which they are energized and brought into contact with the anterior and posterior capsule portions of the aforesaid crystalline lens capsule, respectively, outside the optical path portion for the light being perceived in accordance with the deformation of said crystalline lens capsule to permit the optical lens portion and holding portion to move closer to or farther away from each other.

*Number in the margin indicates pagination in the foreign text.

3. Detailed Specifications

(Technical Fields)

The present invention relates to an intraocular lens used by being inserted into the capsules of a crystalline lens and to an intraocular lens having a focal point adjustment function.

(Background Technology)

The usage of intraocular lenses, which are used as lenses for correcting eyesight following cataract surgery and other lenses, has increased under a large range of clinical evaluations performed in Japan in recent years due to improvements in lenses and developments in surgical techniques. It is confirmed that lenses have much more outstanding functionality than the glasses and contact lenses for cataracts generally used in the past.

Incidentally, such an intraocular lens is an optical element (artificial crystalline lens) inserted into the anterior and posterior chambers of the eyeball as a substitute for a lens extirpated from the eyeball during plastic surgery. As shown in Figure 11, it is generally composed of a biconvex or planoconvex disk-shaped lens main body **2** and a plurality of holding portions **4** that extended integrally from the lens main body **2** for holding the lens main body **2** in a prescribed location inside the eyeball. However, the focal point of a conventional intraocular lens having this structure was fixed; hence, when the focal distance of the

lens was set in accordance with a short distance, there was a problem because the image of an object at a long distance could not be recognized clearly. Conversely, when the focal distance of /280 the lens was set in accordance with a long distance, there was an inherent problem because the image of an object at a short distance could not be perceived distinctly.

Meanwhile, an intraocular lens was proposed in Tokkai no. 63-57044 in recent years so that the focal distance could be adjusted by using a liquid crystal lens and regulating the voltage applied to this liquid crystal lens. According to such an intraocular lens using the liquid crystal lens, the applied voltage is regulated in accordance with the distance to the observed object to correspond the focal distance of the liquid crystal lens to the distance to that observed object; hence, the image of the observed object is formed vividly on the retina regardless of the distance to the observed object to make the observed object thereof more distinctly recognizable.

Incidentally, there were problems with an intraocular lens using the liquid crystal lens illustrated in this bulletin because, in addition to the structure itself of the liquid crystal lens being complex, the configuration thereof was extremely complex, the implementability was low, and so was the practicality since a means for sensing the pupil aperture, a means for arithmetically

processing the distance to the observed object based on the pupil aperture thereof, and a means for applying a voltage corresponding to the arithmetic results of the arithmetic means thereof were required separately for the lens main body (liquid crystal lens).

(Problems to be Solved)

The present invention was achieved at this time with these circumstances as the background. The problem to be solved thereof is an intraocular lens able to substantially adjust the focal length in accordance with the distance to the observed object and to realize an intraocular lens whose structure is simple and with outstanding practicality.

(Solution)

Then, in order to solve such problems, the intraocular lens used by being inserted into a crystalline lens capsule in the present invention is constituted so as to include (a) an optical lens comprising a light-transmitting material having a convex lens function, (b) at least one holding portion wherein the part of it corresponding to the optical path of light being perceived serves as a light transmission-permitting portion to permit the transmission of light, and (c) and a coupling means which elastically couples the optical lens portion and holding portion in a state in which they are energized and brought into contact with the anterior and posterior capsule portions of the aforesaid

crystalline lens capsule, respectively, outside the optical path portion for the light being perceived in accordance with the deformation of said crystalline lens capsule to permit the optical lens portion and holding portion to move closer to or farther away from each other.

(Operation)

With an intraocular lens having this structure, when the ciliary muscles contained in the ciliary bodies in the eyeball are tensed or relaxed, changing the thickness of the crystalline lens capsule, the optical lens portion is displaced forwards and backwards relative to the retina, in accordance with the change in the thickness of that crystalline lens capsule, the focal point of the optical lens portion and then the intraocular lens shifts forward and backwards. As a result, the image of the observed object is formed more vividly on the retina regardless of the distance to that observed object, and the image of that observed object can be recognized more distinctly.

Then, in the present invention, in addition to such a substantial focal point adjustment function being obtained with a simple structure merely by elastically coupling the optical lens portion and holding portion by a coupling means, the operation for such a substantial focal point adjustment is performed based on the original focal point adjustment functions of the eye, i.e., the

tensing or relaxing of the ciliary muscles; hence, the necessity for providing equipment besides the lens itself, as with the intraocular lens disclosed in the aforesaid publication (Tokkai no. 63-57044), can be eliminated.

(Practical Examples)

In order to specifically clarify the present invention even more, practical examples thereof will be explained in detail below on the basis of the drawings.

First of all, an intraocular lens **10**, which is one practical example of the present invention, is shown in Figures 1 and 2. As seen from these drawings, the intraocular lens **10** of this practical example is composed of a lens material **12** serving as the optical /281 lens portion and having a disk-shaped planoconvex lens shape, a rear member **14** serving as the holding portion and having the same disk-shaped planoconvex lens shape, and four flexible loop members **16** serving as the coupling means and coaxially and elastically couple the lens member **12** and rear member **14** to each other at prescribed lengths.

At this time, the lens member **12** is composed of the usual material for forming an intraocular lens having a translucent material, such as polymethyl methacrylate, silicone, hydroxymethyl methacrylate, glass and silicone elastomer. It is constituted with a diameter larger than the aperture diameter of a pupil **20**, which

is the hole in the iris **18** of the eye (see Fig. 3); specifically, it is 4 to 8 mm. Then, as shown in Fig. 2, the convex surface is arranged on the outside, that is, in a state positioned on the opposite side of the rear member **14**.

Moreover, at this time, as shown in Fig. 1, an operation for inserting the intraocular lens **10** into a crystalline lens capsule **22** (see Fig. 3) which will be described later and an alignment operation after that insertion operation are performed easily on the lens member **12**; hence, a plurality (here, four) of through-holes **24** for inserting and catching a hook and the like are formed in positions outside the optical path portion for the light perceived by the retina.

In addition, the aforesaid rear member **14** is composed of the same translucent material as the lens member **12**. Its diameter is also set to a size almost the same as that of the lens member **12**. Then, as with the lens member **12**, the convex surface is arranged on the outside, that is, in a state positioned on the opposite side of the lens member **12**.

Furthermore, the loop member **16** serving as the aforesaid coupling means is composed of a material, such as polymethyl methacrylate, polyvinylidene fluoride, polypropylene, silicone and hydroxyethyl methacrylate, that is formed the shape of the letter U. Then, as shown in Figs. 1 and 2, one end of each of the loop

members protrudes into the mounting holes formed in the outer circumferential portions of the lens member **12** and rear member **14** and deposited and fixed thereto while they turn 90° about the optical axes (central axes) of the lens member **12** and rear member **14**, as observed from the side of the intraocular lens **10**, and are in a slanted state at prescribed angles to the optical axes (optical axis of the intraocular lens **10**) of the lens member **12** and rear member **14**.

Then, at this time, specifically, the thickness of the crystalline lens is normally about 4 mm in an unrestrained state and not inserted into the crystalline lens capsule **22** so that the thickness of the entire intraocular lens **10** is nearly the same as that of the crystalline lens; hence, the lens member **12** and rear member **14** are mutually coupled by these loop members **16** so that the overall thickness is about 3 to 5 mm. As described below, while the intraocular lens **10** is inserted and set inside the crystalline lens **22**, the inside surface (convex surface) of the lens member **12** and the outside surface (convex surface) of the rear member **14** are energized and brought into contact with the anterior capsule portion **26** and posterior capsule portion **28** of the crystalline lens capsule **22**, respectively, on the basis of on the elastic forces of the respective loop members **16**.

Moreover, the end of each of the aforesaid loop members **16** is formed in a position separated from the optical path portion for the light perceived by the retina so that the mounting holes of the lens member **12** and rear member **14** do not prohibit vision as with the through-hole **24** formed in the aforesaid lens member **12** that protrude inward and are deposited and fixed.

Incidentally, as shown in Fig. 3, the intraocular lens **10** is inserted into the crystalline lens capsule **22** subsequent to extirpation of the nucleus and cortex from the crystalline lens capsule **22** so that, with respect to the incision opening of the crystalline lens capsule **22** through which the nucleus and cortex are extirpated, the lens member **12** is positioned on the anterior capsule portion **26** side of the crystalline lens capsule **22** and the rear member **14** is positioned on the posterior capsule portion **28** side of the crystalline lens capsule **22** and then the intraocular lens is aligned inside the crystalline lens capsule **22** so that the optical axes of the lens member **12** and rear member **14** coincide with the optical axis of the eyeball.

Moreover, based on the elastic forces of the loop members **16**, as described above, since the outside convex surface of the lens member **12** is energized and brought into contact with the anterior capsule portion **26** of the crystalline lens capsule **22** and the outside convex surface of the rear member **14** is energized and

brought into contact with the posterior capsule portion **28** of the crystalline lens capsule **22**, respectively, the intraocular lens **10** inserted and set inside such a crystalline lens capsule **22** is stabilized in a set position inside the crystalline lens capsule **22** where it is held. /282

In addition, at this time, the operation for inserting and setting the intraocular lens **10** inside the crystalline lens capsule **22** is performed by inserting and catching a hook or the like via the through-hole **24** formed in the lens member **12**, as described above.

The intraocular lens **10** inserted and set inside the crystalline lens capsule **22** of the eyeball in this way is held in the set position while it is energized and brought into contact with the anterior capsule portion **26** of the crystalline lens capsule **22** with the outside convex surface of the lens member **12** on the basis of the elastic forces of the loop members **16**, on the one hand, and also energized and brought into contact with the posterior capsule portion **28** of the crystalline lens capsule **22** on the outside convex surface of the rear member **14**.

Therefore, when the thickness of the crystalline lens capsule **22** changes due to the tensing or relaxing of the ciliary muscles of the ciliary bodies **30**, the lens member **12** and rear member **14** of the intraocular lens **10** move closer to or farther away from each other

in accordance with that change in the thickness of the crystalline lens capsule **22** and on the basis of the elastic force of the loop member **16** or against the force of the loop member **16**. As a result, the lens member **12** and rear member **14** move closer to or farther away from the retina, respectively. Then, as a result of the lens member **12** and rear member **14** moving closer to or farther away from the retina, respectively, the focal position of the entire intraocular lens **10** comprising the lens member **12** and rear member **14** moves relatively forwards and backwards with respect to the retina.

That is, when the ciliary muscles tense or relax due a change in the distance to an observed object, the focal point of the intraocular lens **10** moves forwards and backwards in accordance with the change in the distance to that observed object. Thus, the image of that observed object is formed more vividly on the retina than through a conventional intraocular lens having a fixed focal point. Accordingly, the image of the observed object can be perceived and recognized clearly regardless of the distance to that observed image, and moreover, its structure is extremely simple and no special maintenance is particularly required; hence, it is excellent for practical use.

Moreover, in the intraocular lens **10** in the above example, the loop members **16** serving as the coupling means are provided while

they respectively with respect to the optical axis of the intraocular lens **10** (the optical axes of the lens member **12** and rear member **14**) as seen from the side of the intraocular lens **10**. But as shown in Figs. 4 and 5 and as seen from the side of the intraocular lens **10**, it is also possible to provide four loop members **16** so that they match the optical axis of the intraocular lens **10** thereof. Additionally, as shown in Figs. 6, 7 and 8, it is also possible to elastically couple the lens member **12** and rear member **14** with loop members **16** formed in the shape of an arrow, vane or letter V. Furthermore, the coupling means elastically couples the lens member **12** and rear member **14** outside the optical path of the light perceived by the retina and it does not scratch the tissues of the eye, such as the crystalline lens **22**. While the intraocular lens **10** is set inside the crystalline lens capsule **22**, since the lens member **12** and rear member **14** are energized and brought into contact with the anterior capsule portion **26** and posterior capsule portion **28** of the crystalline lens capsule **22**, the lens member **12** and rear member **14** can be permitted to move closer to or farther away from [each other] along with a change in the thickness of the crystalline lens capsule **22**. But when the loop members **16** are used as the coupling means thereof, it is desirable to provide the loop members **16** in a state in which they slant with respect to the optical axis of the intraocular lens **10**

as seen form the side of the lens **10** so that they do not get caught on the intraocular lens **10** when it is being inserted into the crystalline lens capsule **22**, as with the intraocular lens **10** shown in Figs. 1 and 2. In addition, the lens member **12** and rear member **14** are held in a coaxial state so that they move closer to or farther apart from each other; hence, as shown in Figs. 1 and 8, it is desirable to use the plurality of loop members **16** as a set.

Additionally, in the intraocular lens **10** in the aforesaid practical example, the convex lens function of the lens member **12** is given to both the lens member **12** serving as the optical lens portion and the rear member **14** serving as the holding portion, but it is not always necessary to maintain the convex lens function by using the rear member **14** as the holding portion. For example, as shown in Fig. 9, it is also possible to adopt a flat disk-shaped rear member as the rear member **14**. In addition, as shown in /283 Figs. 4 and 5, it is also possible to adopt an optical lens having a structure in which the portion corresponding to the optical path portion for light perceived by the retina serves as a through-hole **32**. In the intraocular lens shown in Figs. 4 and 5, the through-hole **32** serves as the light transmission-permitting portion.

However, at this time, as with the intraocular lens **10** in the aforesaid practical example, in giving a convex lens function to not only the lens member **12**, as the optical lens portion, but also

the rear member **14**, as the holding portion, the convex lens functions (refractive indexes) of either of the lens member **12** or rear member **14** can be increased when the focal position of the entire intraocular lens changes in accordance with the change in the thickness of the crystalline lens capsule **22**, but due to the fact that one convex lens function is sufficiently smaller than the other convex lens function, the lens member **12** is distributed to the anterior capsule portion **26** ~~side or the pos~~terior capsule portion **28** side of the crystalline lens capsule **22**. It is more desirable to maintain the convex lens function with the lens member **12** only so that it is a smaller convex lens function and an efficient focal point adjustment function is obtained.

Furthermore, according to the aforesaid practical example, the rear member **14** comes in direct contact with the posterior capsule portion **28** of the crystalline lens capsule **22** at the outside convex surface thereof, but it is not always necessary that the rear member **14** come in direct contact with the posterior capsule portion **28** of the crystalline lens capsule **22** at the outside surface thereof. For example, as shown in Fig. 10, a protruding portion **34** is provided on outer circumferential part on the outside surface of the rear member **14** outside the optical path for the perceived light and a prescribed gap is provided between the outside surface of the rear member **14** and the posterior capsule portion **28** of the

crystalline lens capsule **22**. By doing this, focusing of a laser beam on the rear member **14** is successfully avoided during a treatment for late cataract by laser irradiation and it is possible to satisfactory prevent the rear member **14** from being damaged by the laser beam.

Furthermore, in the aforesaid practical example, the lens member **12** had a planoconvex lens shape, but this lens member **12** can have a biconvex lens shape or a meniscus shape.

However, when there is the fear of close contact between the lens member **12** and rear member **14** due to the surface tension or adhesive force of the pressure-sensitive substance when a pressure-sensitive substance is used at the time of insertion into the crystalline lens capsule **22**, it is desirable to use, e.g., a meniscus-shaped lens member as the lens member **12** so that a gap can be provided between the lens member **12** and rear member **14**. It is also desirable to provide a protruding portion on at least one outer circumferential portion of the mutually opposing surfaces of the lens member **12** and rear member **14** when a planoconvex lens-shaped or biconvex lens-shaped lens member **12** is adopted so that a prescribed gap can be provided between the lens member **12** and rear member **14**.

Additionally, it is desirable that the rear member **14** serving as the holding portion, as with the intraocular lens **10** in the

aforesaid practical example, achieve a diameter nearly equal to the lens member **12** serving as the optical lense portion so that the incision of the crystalline lens capsule **22** is not larger than necessary and the intraocular lens **10** is stably held in a set position inside the crystalline lens capsule **22** when the intraocular lens **10** is inserted into the crystalline lens **22**. But this diameter is not always limited to a diameter equal to that of the lens member **12** during and after insertion of the intraocular lens into the crystalline lens capsule **22** if the intraocular lens **10** can be stably held in the set position thereof without scratching the crystalline lens capsule **22**.

Other than leaving out enumerated separate specific examples, it goes without saying that the present invention can be carried out in embodiments in which various modifications, revision, improvements, and the like can be applied in a range without compromising the spirit thereof.

(Advantages of the Invention)

As seen from the above explanations, in the intraocular lens in according to the present invention, the focal distance of the lense can be adjusted substantially in accordance with the distance to the observed object by using an extremely simple structure having only a lens main body which is inserted and set in the crystalline lens. Accordingly, the great industrial significance

of the present invention rests with the ability to realize an automatic focal point adjustment function with an extremely simple structure.

4. Brief Description of the Figures

Figure 1 is a top view showing an example of the intraocular lens in accordance with the present invention; **Figure 2** is a front view thereof; and **Figure 3** is an explanatory view showing the set /284 state of the intraocular lens in Fig. 1 inside the crystalline lens capsule. **Figure 4** is a drawing corresponding to Fig. 1 showing another example of the intraocular lens in accordance with the present invention and **Figure 5** is a partial cutaway front view of the intraocular lens in Fig. 4. **Figures 6** to **8** are respective front views schematically showing even more examples of the intraocular lens in accordance with the present invention. **Figure 9** is a perspective view showing an example of the reverse member adoptable as the holding portion of the intraocular lens in accordance with the present invention; **Figure 10** is a cross section showing yet another example of the reverse member adoptable as the holding portion. **Figure 11** is a top view showing an example of a conventional intraocular lens.

10: intraocular lens; 12: lens member (optical lens portion); 14: rear member (holding portion); 16: loop member (coupling means); 22: crystalline lens capsule; 26: anterior capsule portion;

28: posterior capsule portion; 30: ciliary body; 32: through-hole (light transmission-permitting portion)

Figure 1

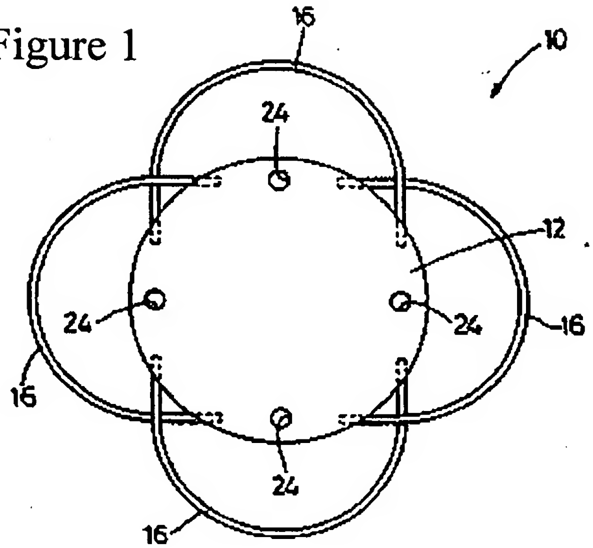

Figure 2

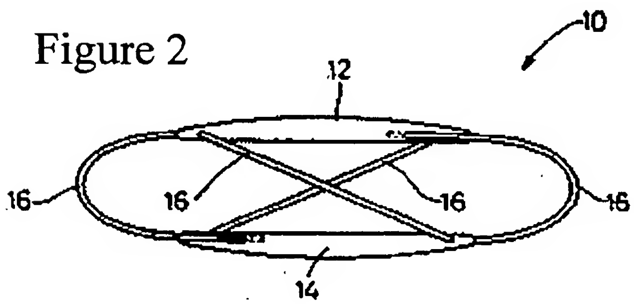

Figure 3

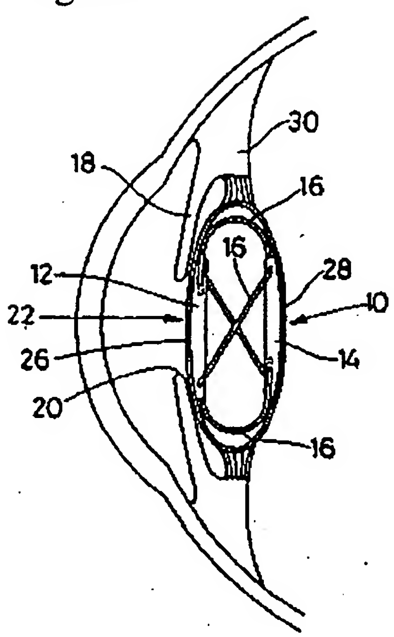

Figure 4

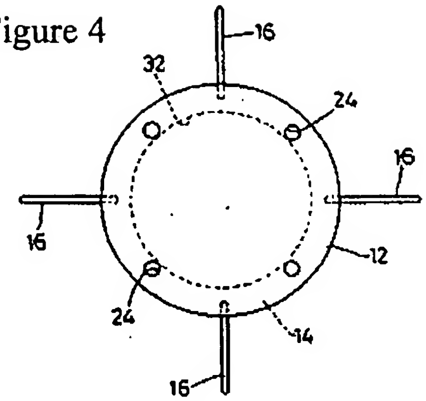

Figure 5

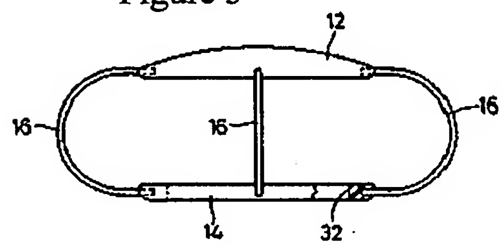

Figure 6

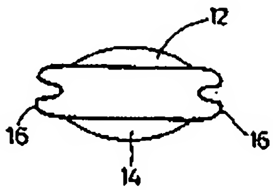

Figure 7

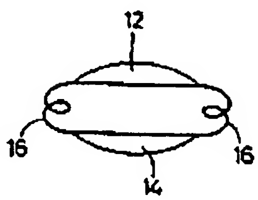

Figure 8

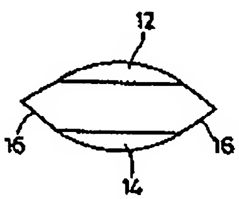

Figure 9

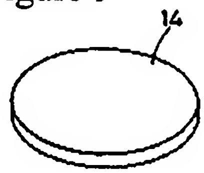

Figure 10

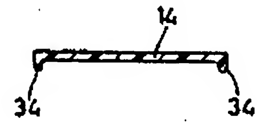

Figure 11